

Lesson 8 – Geometry shaders

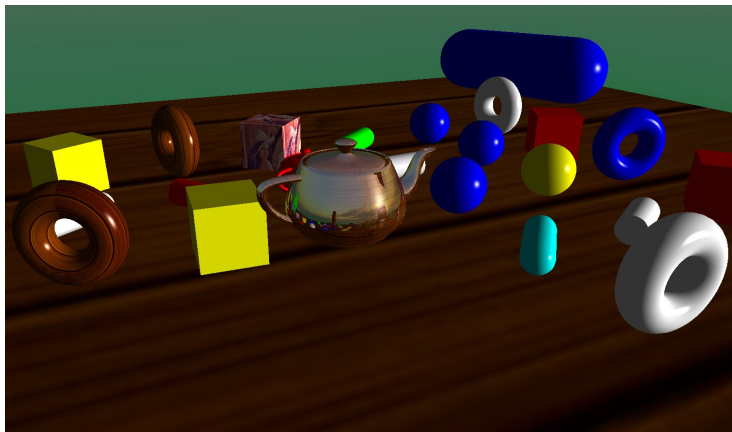
Environment mapping

PV227 – GPU Rendering

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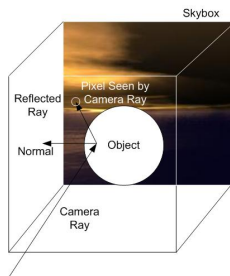
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Intermezzo – Environment mapping



Reflections: Environment mapping

Environment mapping



Source: Wikipedia

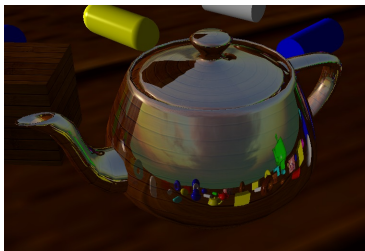
- $\overrightarrow{ReflectedRay} = \overrightarrow{CameraRay} - 2 \cdot \vec{N} \cdot \text{dot}(\vec{N}, \overrightarrow{CameraRay})$
- In GLSL: $\text{ReflectedRay} = \text{reflect}(\text{CameraRay}, N)$
- Assumes N is normalized

Task: Implement environment mapping

- **Task 1:** Implement environment mapping in *reflection_fragment.glsl*
 - ▶ Mix the environment reflection with the color of the object

Updating the cube map

- When the surrounding changes, the cube map with the environment should be updated.
- Six faces of the cube map means:
 - ▶ six cameras,
 - ▶ six framebuffer objects
 - ▶ six times traversing the scene
- Already implemented in the code.



Layered rendering

- Renders into multiple textures at the same time
 - ▶ Good for cube maps, stereo rendering etc.
- Different from attachments of FBOs
 - ▶ Attachments: Primitives are rasterized at the same places
 - ▶ Layers: Each layer has different primitives
- Renders triangles into layered textures:
 - ▶ cube maps (6 layers)
 - ▶ 2D texture arrays
 - ▶ 3D textures, 1D texture arrays, cube map arrays
- Use *glFramebufferTexture* to attach a layered texture into a framebuffer
 - ▶ All textures at all attachments must be layered
- Another usage of geometry shaders
- New output variable in geometry shaders: *gl_Layer*
 - ▶ Specifies the index of the layer into which the primitive is sent

Updating the cube map – layered rendering

- Updating all faces simultaneously means:
 - ▶ six cameras available at the same time
 - ▶ one framebuffer object with all faces
 - ▶ traversing the scene once
 - ▶ special vertex and geometry shaders

Task: Implement layered rendering

- **Task 2:** Implement layered rendering in *texture_to_cube_geometry.glsl* and compare the rendering speed
 - ▶ Generate 6 triangles (18 vertices), one for each face
 - ▶ Some vertex data do not change, they are computed in VS
 - ★ Pass them through geometry shader without change
 - ▶ Some vertex data (*gl_Position* and *gl_Layer*) are different for each face.
 - ★ Compute their values in geometry shader
- **Optional task:** Implement the same for the skybox in *skybox_to_cube_geometry.glsl*
- Test on the central object, use cube or sphere without reflections

Instanced geometry shader

- Problem: the geometry shader processes 18 vertices sequentially, not in parallel
- Possible solution: Instanced geometry shaders
 - ▶ Similar to instancing
 - ▶ Geometry shader is run multiple times per each input primitive
 - ▶ In GS: Instances = Invocations
 - ▶ Defined in geometry shader:
 - layout (triangles, invocations = 6) in;*
 - layout (triangle_strip, max_vertices = 3) out;*
 - ▶ Special variable *gl_InvocationID*:
 - ★ Only in geometry shader
 - ★ Similar to *gl_InstanceID*

Task: Implement instanced geometry shaders

- **Task 3:** Implement instanced geometry shaders in *texture_to_cube_invocations_geometry.glsl* and compare the rendering speed
 - ▶ Generate 1 triangle (3 vertices), 6 invocations, one invocation for each face
- **Optional task:** Implement the same for the skybox in *skybox_to_cube_invocations_geometry.glsl*

Parallelize even more

- Use instancing, i.e. render each object six times.
- Everything is computed in vertex shader, all vertices in parallel
- Geometry shader only copies the data of each vertex and sets *gl_Layer*
- **Task 4:** Implement this in *texture_to_cube_instancing_vertex.glsl* and *texture_to_cube_instancing_geometry.glsl* and compare the rendering speed
 - ▶ **Option:** Implement the same for the skybox in *skybox_to_cube_instancing_vertex.glsl* and *skybox_to_cube_instancing_geometry.glsl*

Parallelize even more, skip geometry shaders

- Modern graphics card may set *gl_Layer* also in vertex shaders, thus skipping the geometry shader completely
 - ▶ We need OpenGL extension *GL_ARB_shader_viewport_layer_array*, unfortunately, it is not available on computers in B311
 - ★ No, it **is** available, hurray!
- **Optional task 5:** Implement this in *texture_to_cube_instancing_no_gs_vertex.glsl* and in *skybox_to_cube_instancing_no_gs_vertex.glsl* and compare the rendering speed

Geometry Shaders Today

- not for tessellation, surpassed by tessellation shaders
- probably not for culling (not necessary)
- expanding a point to a quad (particle systems), compete with instancing
- expanding a line to a quad (grass, hair), in combination with tessellation shaders
- transform feedback (outputs vertices back into VBOs)
- layered rendering, instanced geometry shaders
 - ▶ not enough parallel, compete with instancing, not necessary when *gl_Layer* is set in vertex shaders